

# Francesco Volpe

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## Education

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|---------------------------|---|-------------|
| <b>Ph.D.</b>              | <b>Experimental Physics, <i>Summa cum Laude</i></b><br><b>Ernst Moritz Arndt Universität Greifswald</b> (Germany) and<br>International Max Planck Research School on Bounded Plasmas (IMPRS), Greifswald.<br>Thesis at the Max-Planck Institut für Plasmaphysik (IPP), Garching (Germany):<br><i>Electron Bernstein emission diagnostic of electron temperature profile at W7-AS Stellarator</i> . Supervisors: H.P.Laqua and F.Wagner. | <b>2003</b> |
| <b>Laurea<br/>(M.Sc.)</b> | <b>Physics, 110 out of 110 <i>cum Laude</i></b><br><b>University of Pisa</b> (Italy)<br>Curricula included: Plasma Physics, Statistical Mechanics, Quantum Field Theory, Experimental High Energy Physics.<br>Thesis at ENEA Frascati:<br><i>Scattering collettivo di onde millimetriche per la misura della temperatura ionica sul tokamak FTU</i> . Supervisors: F.P.Orsitto and F.Pegoraro.  | <b>1998</b> |
| <b>High School</b>        | <b>“Liceo Scientifico T.L.Caro”, Napoli</b> (Italy), <i>60 out of 60</i>  | <b>1992</b> |

## Further Education

- |             |                          |                                       |   |
|-------------|--------------------------|---------------------------------------|---|
| <b>2009</b> | 23-25 June               | Nashville, USA                        | 13th Annual STEM Education Scholars Program, organized by CIRTL and hosted by Vanderbilt University   |
| <b>2008</b> | 3-11 Nov.<br>7-15 Jan.   | Garching, Germany<br>Los Angeles, USA | EFDA “GOTiT” <i>Course on Gyrokinetics</i> by B. Scott<br><i>Winter School 2008 on Instabilities in Laboratory, Space and Astrophysical Plasmas</i> at UCLA |
| <b>2006</b> | 23 Feb.                  | Greifswald, Germany                   | <i>Project Management Course</i> organized by IMPRS at the Institut für Niedertemperatur-Plasmaphysik Greifswald  |
| <b>2005</b> | Oct.-Nov.                | Culham, U.K.                          | <i>Bayesian Analysis</i>  |
| <b>2004</b> | 13-17 Dec.<br>9 November | Culham, U.K.<br>London, U.K.          | <i>MAST Session Leader<sup>1</sup> Training</i><br><i>FEMLAB Hands on Training</i>  |

<sup>1</sup>A session leader, a.k.a. physics operator, leads an experimental session (half a day, or a whole day). He programs the current in the coils, the gas injection, the density and position feedbacks and gives directives to the pellet, heating and data acquisition operators. His aim is to create a plasma with certain characteristics of density, temperature, shape etc., agreed with the physicists in charge for the experiment.

|             |                 |                     |  |
|-------------|-----------------|---------------------|--|
|             | 19-30 July      | Culham, U.K.        | <i>41st Culham Plasma Physics Summer School</i>  |
|             | 27-29 April     | Tubney Woods, U.K.  | Oxford Instruments<br><i>Practical aspects of Magnets, Cryogenics, Thermometry and Vacuum</i>                          |
| <b>2001</b> | 10-21 Sept.     | Bad Honnef, Germany | <i>5th Carolus Magnus Euro-Summer School on Plasma and Fusion Energy Physics</i>                                       |
|             | 25-29 June      | Greifswald, Germany | <i>Ionospheric Plasma Physics</i> (Prof.Schlegel, MPAE Lindau), organized by IMPRS Greifswald                          |
| <b>1999</b> | 25 Oct.-19 Nov. | Trieste, Italy      | Abdus Salam International Centre for Theor. Physics<br><i>Autumn College on Plasma Physics</i>                         |
| <b>1998</b> | 7-11 Sept.      | Udine, Italy        | CISM International Centre for Mechanical Sciences<br><i>IUTAM School "Advanced Turbulent Flow Computations"</i>        |
| <b>1997</b> | 6-10 Oct.       | Greifswald, Germany | <i>Summer University for Plasma Physics</i> , organized by the Max-Planck-Institut für Plasmaphysik, Garching, Germany |

## Research

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### Research Interests

Plasma Physics and Magnetic Confinement Fusion (Tokamaks and Stellarators) both experimentally and via numerical modelling, with emphasis on:

- Microwave Heating, Current Drive and Diagnostics
- Magnetohydrodynamic Instabilities and their Control

### Chronological Summary

|  |   |
|--|---|
| Apr <b>09</b> - date<br><b>Assistant Professor</b>   | <b>University of Wisconsin, Madison, U.S.A.</b><br>Experiment on the dependence of Neoclassical Tearing Modes (NTMs) on impurities and wall conditioning in the NSTX spherical torus at PPPL Princeton.   |
| Dec <b>08</b> - Mar <b>09</b><br><b>Self-employed</b>  | <b>Madison, WI, U.S.A. and Naples, Italy</b><br>Worked on finishing a DIII-D and a theoretical paper while waiting for a visa.  |
| Apr <b>08</b> - Nov <b>08</b><br><b>Staff Physicist</b><br>Subject:<br>Group leader:<br>Main results/activities: | <b>IPP, Garching, Germany</b><br>Electron Cyclotron Reson. Heating (ECRH) in ASDEX Upgrade Tokamak<br><i>J. Stober</i><br>- served as ECRH operator<br>- developed faster version of TORBEAM tracing code (from 1.5s to 66ms) for applications to real-time steering of ECRH aimed at MHD control<br>- studied feasibility of Electron Bernstein Wave Current Drive system for the RFX-mod reversed field pinch ( <i>with R. Bilato and A. Köhn</i> of IPF Stuttgart) |
| Apr <b>07</b> - Apr <b>08</b><br><b>Post-doc</b> , Oak Ridge Associated Universities (ORAU)                      | <b>General Atomics, San Diego, U.S.A.</b>   |

Subject: Diagnosis and control of locked and rotating NTMs at the DIII-D tokamak  
Supervisors: *E.J. Strait, R.J. La Haye, R. Prater*  
Main results/activities: - **first stabilization of  $m/n=3/2$  NTM by Electron Cyclotron Current Drive (ECCD) modulated and radially aligned by means of oblique Electron Cyclotron Emission (ECE)**,  
- sustained NTM rotation at up to 180Hz by means of rotating fields,  
- explained retrograde motion and period changing when applied fields are too weak,  
- shown by ray tracing necessity of magnetic control of locked modes to assist their ECCD stabilization in ITER,  
- reproduced Locked Mode Mitigation (see below),  
- tutored student (*H.Rinderknecht*) in least square and linear algebra tomographic inverters for Soft X-rays, with innovative tessellation and automatic initial guess.

External: - Spinning mirror Electron Bernstein Wave (EBW) measurements (Apr.07) and analysis (Nov.07), MAST spherical tokamak, Culham, UK.

Apr 06 - Mar 07      **General Atomics, San Diego, U.S.A.**  
**Visitor (Otto-Hahn Medal** of the Max-Planck Gesellschaft, Germany)  
Subject: Diagnosis and control of locked and rotating NTMs at DIII-D  
Supervisors: *R. Prater, R.J. La Haye, E.J. Strait*  
Main results/activities: - magnetically unlocked and repositioned a locked NTM at DIII-D Tokamak by means of magnetic perturbations exerted by internal coils, then mitigated the mode by means of ECCD,  
- sustained NTM rotation at up to 60Hz by means of rotating fields,  
- developed and installed a radial and phase detector of NTMs from oblique ECE for direct, phase-locked modulation of ECCD in island O-point (*with M.Austin*)  
- analyzed horizontal ECE measurements of NTMs.

Jan 06 - Mar 06      **IPP, Greifswald, Germany**  
**Fortbildungsstipendium (Advanced Training Scholarship)**  
Analytic work: - novel formulation of weakly relativistic dielectric tensor valid for arbitrary wavenumbers.  
Numerical work: - incorporated EBW and mode conversion physics in ray tracing code for W7-X stellarator (*with N.Marushchenko*).  
- interfaced the code to EFIT tokamak equilibria (*with Yu.Turkin*).

Nov 04 - Dec 05      **UKAEA Fusion, Culham, U.K.**  
**Physicist - Microwave Diagnostics and Heating, Fircroft**  
Subject 1: Spinning mirror for fast angular scan of EBW emission  
Co-workers: *J. Storrs, V. Shevchenko*  
Main results/activities: - prototyped 12,000rpm spinning mirror

Subject 2: Optimization of ITER ECRH Upper Launcher for NTM stabilisation  
Main results/activities: - analysed resiliency to steering errors and changes of profiles,  
- set limits for alignment,  
- predicted radial coverage in combination with equatorial launcher.

Other: - served as MAST Session Leader<sup>1</sup> (*trained by G.Cunningham et al.*),  
- proposed more efficient variant of double-null-merging non-solenoid startup,

External: - participated in Collective Thomson Scattering (CTS) campaign at FTU: gyrotron perturbations explained with reflection at X-mode cutoff layer; pointed out that experimental spectra are convolutions, rather than sums, of CTS and gyrotron spectra (*with U.Tartari et al.*)

Nov **02** - Oct **04**      **UKAEA Fusion, Culham, U.K.**

**Post-doctoral "Marie Curie" Fellow**

Subject 1: EBW studies in the MAST spherical tokamak,

Supervisor: *V. Shevchenko*

Main activities/results: - installed COMPASS radiometer on MAST and connected to steering heating antenna,  
- angular scans of emission to optimise plasma target and launch geometry for EBW heating experiments at 60GHz, which then led to evidence of OX mode coupling,  
- measured ELMs-generated heat waves,  
- observed non-thermal emission at sawtooth crashes,  
- observed banded emission during ohmic plasma compression,  
- Fokker-Planck predictions of EBW Current Drive (CD) for future lower frequency system, with emphasis on edge Ohkawa CD and applications such as ELMs control.

Subject 2: Optimization of ITER ECRH Upper Launcher for NTM stabilisation

Supervisor: *B. Lloyd*

Main activities/results: - ray tracing and Fokker-Planck modelling, including astigmatism,  
- shown better performance of lower row of mirrors,  
- studied effect of density and temperature variations,  
- non-linearities at high power shown negligible.

Other: - designed refractive optics for MAST Interferometer,  
- explained degradation of JET Interferometer signals during ELMs as due to deflection from plasma.

Dec **98** - Oct **02**      **IPP, Garching bei München, Germany**

**Doctoral student**

Subject: EBW Emission (EBE) at the Wendelstein 7-AS (W7-AS) stellarator.

Supervisor: *H.P. Laqua*

Main results/activities: - **first EBE diagnostic of electron temperature profiles, i.e. first extension of ECE to overdense plasmas**  
- **first heat waves generated by EBW heating and measured by EBW emission**  
- optimised antenna to yield maximum Bernstein-Extraordinary-Ordinary (BXO) mode conversion efficiency, modal purity and minimum Doppler shift despite oblique view necessary for BXO  
- compared broadband polarisers, adopted elliptical waveguide  
- developed 3D ray tracing code for mode-converted EBWs in stellarators using warm plasma dielectric tensor,  
- applied the code to antenna design and analysis of EBE spectra,  
- measured confinement transitions, edge localised modes and radiative collapses,  
- analytical solution of OX conversion,  
- ray tracing analysis of first EBW Current Drive based on OXB conversion

May **98** - Nov **98**  
**Borsista (Scholar)**

**Consorzio di Magnetofluidodinamica, University of Trieste, Italy**

Subject: Liquid metals  
Supervisor: V. Armenio  
Main results/activities: - developed a 2D finite difference code for flows of industrial interest

Mar **97** - Apr **98**      **ENEA, Frascati (Rome), Italy**

**Undergraduate student**

Subject: Collective Thomson Scattering (CTS) experiments at the FTU tokamak.  
Supervisor: F.P. Orsitto  
Main results/activities: - calibrated radiometer and surveyed its stability,  
- inferred ion temperature and molybdenum content from CTS spectrum,  
- studied CTS “geometrical form factor” close to cutoffs and resonances,  
- measured and interpreted oblique suprathermal ECE during Lower Hybrid Current Drive.

Furthermore, brief visits of 1-2 weeks were paid, under the EURATOM staff movements scheme, to:

- EPFL-CRPP Lausanne, Switzerland (July 2003),  
to install the ray tracing code for mode-converted EBWs ART for TCV tokamak and stellarator reactors
- IPP Greifswald, Germany (February 2004),  
to install the ray tracing code for mode-converted EBWs ART for the W7-X and WEGA stellarators
- ENEA Frascati, Italy (April 2005),  
to take part in the Collective Thomson Scattering (CTS) campaign on the FTU tokamak
- IFP-CNR Milan, Italy (May 2005),  
to discuss and analyse experimental results from the CTS campaign at FTU

## Teaching and mentoring

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### Classes

**Fall 2009**    **ECE/NEEP/Phys 525 - Introduction to Plasmas**

Cross-listed between Electrical and Computer Engineering (ECE), Nuclear Engineering - Engineering Physics (NEEP) and Physics (Phys).

Level: graduate and advanced undergraduate. 36 students.

### Lecturing

Lecture on “Plasma Waves and Heating” at the  
IPP Summer University on Plasma Physics and Fusion Research, 22-26 Sept. 2008 Garching (Germany)

### Supervised graduate students

**2009-date**    **François Beaude** (University of Wisconsin, Madison).  
*Electron Bernstein Waves in the Pegasus Spherical Tokamak*

## Supervised undergraduates

- 2009**     **Jonathan Kessler** (Southeast Missouri State University) on a visit to General Atomics, Fusion Group under the auspices of the National Undergraduate Fellowship (NUF) Program. *Magnetic Transport Barriers from Large Coalescing Islands*.  
Work to be presented at the 51st APS Annual Meeting of the Division of Plasma Physics [Bull. Am. Phys. Soc. , **54** (2009)].
- 2007**     **Hans Rinderknecht** (Princeton University) on a visit to General Atomics, Fusion Group under the auspices of the NUF Program. *Soft X-Ray Tomography at DIII-D*.  
Work presented at the 49th APS Annual Meeting of the Division of Plasma Physics [Bull. Am. Phys. Soc. , **52**, No.16, p.154, JP8 18 (2007)].  
Published in J.P. Qian *et al.*, “Equilibrium reconstruction of plasma profiles based on soft x-ray imaging in DIII-D”, *Nucl. Fusion* **49**, 025003 (2009).
- 2000-01**   **2 groups of 2 students** in a plasma interferometry experiment in partial fulfillment of the requirements for the degree of “Diplom-Physiker” at the Technische Universität München. Contacts: Prof.H.J.Körner (TUM) and Dr.K.H.Steuer (IPP Garching).

## Other activities

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### Reviewer for

|                              |  |
|------------------------------|--|
| Czech Science Foundation     | <b>2004</b>                              |
| Fusion Sci. Technol.         | <b>2009</b>                              |
| J.Phys.D: Appl. Phys.        | <b>2007</b>                              |
| Nuclear Fusion               | <b>2003, 2007</b> (×2), <b>2009</b> (×2) |
| Physics Letters A            | <b>2006</b>                              |
| Plasma Phys. Control. Fusion | <b>2007, 2008, 2009</b> (×2)             |
| Plasma Sources Sci. Technol. | <b>2008</b>                              |

### Service at UW-Madison

Member of committee for M.Sc. dissertation defense “Isolating Pseudowaves for use in determining relative Ion Concentrations in a Multi-Ion Species Plasma” by John P. Sheehan.

### Outreach

- 2006-07**   ”Scientist in the Classroom”: lectures and demonstrations organised by PPPL and General Atomics in schools of Southern California
- 2004-05**   Toured dozens of groups (hundreds of visitors) from schools, universities and general public around MAST and COMPASS tokamaks at Culham, UK.

## Other skills and information

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### IT skills

- numerical methods for wave propagation (e.g. ray tracing)
- other programs developed: finite-difference solvers of partial differential equations (CFD and liquid metal MHD), data acquisition (such as interfacing to ADC) and elaboration (such as noise filtering)

- scientific programming in Fortran90, IDL, Mathematica and Matlab
- parallel computing in PVM
- familiarity with the following scientific and visualization software:
  - *Fusion-specific:*
    - \* Data Visualiz.: `cview` (ASDEX Upgrade), `nmul` (W7-AS), `gaprofiles` and `Reviewplus` (DIII-D), `shox` (FTU), `scope` (NSTX), `xpad6` (MAST)
    - \* Electron Cyclotron: `ART`, `BANDIT-3D`, `ECHRES` (`toray-ga` on EFIT equilibrium), `toray-ga`, `TORBEAM`, `TRAVIS`
    - \* Equilibrium/Magnetic Configurations: `EFIT`, `FIESTA`, `Scene`, `TRANS`
    - \* MHD analysis at DIII-D: `lock`, `mode1`, `newspec`, `rwm`, `slcontour`
    - \* Other: `autoonetwo` (transport), `PCS` (Plasma Control System)
  - *General:*
    - \* CAD: `AutoCAD 2006`, `Claris-CAD`, `MEDUSA`
    - \* Finite Elements, Computational Fluid Dynamics: `FEMLAB/Comsol`
    - \* Graphics Editors: `Corel Draw`, `gimp`, `ImageMagik`, `xfig`, `xpaint`
    - \* Libraries: `NAg`
    - \* Project Management: `Microsoft Project`
    - \* Spreadsheets, Data Analysis and Plotting: `Excel`, `gnuplot`, `IGOR`, `Kaleida Graph`, `Origin`, `PAW` (Physics Analysis Workst., CERN), `Tecplot`, `xmgr`

## Languages

|                |                  |   |
|----------------|------------------|---|
| <b>Italian</b> |                  | mother tongue   |
| <b>English</b> | <b>2008</b>      | Pronunciation class at University of California San Diego "Extension"   |
|                | <b>2004</b>      | Certificate in English Language Skills (CELS) "Higher" <sup>2</sup> English for Speakers of Other Languages (ESOL), University of Cambridge<br>Reading: Pass with Merit, Writing: Pass with Merit, Listening: Pass with Merit, Speaking: Pass |
|                | <b>2003-2004</b> | English class (ESOL level 2) at Oxford & Cherwell College, Oxford   |
|                | <b>2003-2008</b> | 3 years living in England + 2 in the USA  |
|                | <b>1984-1992</b> | English at school   |
| <b>German</b>  | <b>2000</b>      | <i>Zertifikat Deutsch</i> <sup>3</sup> , Goethe Institut München<br>Reading + Writing + Listening: 191.5 out of 225. Speaking: 58 out of 75. Total: "gut"   |
|                | <b>1999-2002</b> | German classes at Goethe Institut München up to upper-intermediate level (M3b <sup>4</sup> )  |
|                | <b>1998-2002</b> | 4 years living in Germany   |
| <b>Spanish</b> | <b>2006-2007</b> | Spanish classes at the University of California San Diego "Extension"   |

## Honours, fellowships and awards

**2007** Oak Ridge Associated Universities (ORAU) Fellowship

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<sup>2</sup> equivalent to Certificate for Advanced English (CAE), C1 Effective Operational Proficiency Level of the Council of Europe

<sup>3</sup> B1 Threshold Level of the Council of Europe

<sup>4</sup> C1 Effective Operational Proficiency Level of the Council of Europe

- 2003** Otto-Hahn Medal of the Max-Planck Gesellschaft (Germany) for one of the most outstanding doctoral theses of the year
- 2002** Marie Curie Individual Fellowship (category 30, area NUC-Nuclear Energy) of the European Commission Research Directorate DG XII, 5th Framework Programme

### Alumni Associations

- since **2007** University of Pisa, Physics Department (Italy). Attended: 1993-1997.
- since **2005** International Max-Planck Research School (IMPRS) on Bounded Plasmas (Germany). Attended: 1998-2003.

### Professional Memberships

- since **2008** American Physical Society (APS) and its Division of Plasma Physics (DPP)

## Invited talks

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For the whole list of talks and presentations see <http://silver.neep.wisc.edu/~volpe/Publ/1Pres.pdf>

- *Advanced Techniques for Neoclassical Tearing Mode Control in DIII-D*  
invited to the 50th Annual Meeting of the Division of Plasma Physics of the American Physical Society (APS), Dallas, TX (USA), 17-21 November 2008
- *ART: a Ray-Tracing Code for mode-converted Electron Bernstein Waves in Tokamaks and Stellarators*  
invited to the meeting of the IMP5 Project (Fast Particles and Heating) of the EFDA Integrated Tokamak Modelling Task Force (ITM-TF), Cadarache (France), 10-11 January 2006
- *BXO mode-converted electron Bernstein emission diagnostic of electron temperature profiles at W7-AS Stellarator*  
invited to the 14th Topical Conference on High Temperature Plasma Diagnostics (HTPD 2002) Madison, WI (USA), 8-11 July 2002
- *Electron Bernstein emission diagnostic of electron temperature profiles at W7-AS Stellarator*  
invited to the International Conference on Advanced Diagnostics for Magnetic and Inertial Fusion Villa Monastero, Varenna (Italy), 3-7 September 2001

## Selected Publications

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For the whole list of 29 refereed publications, 2 recently submitted articles and 69 conference papers and reports see: <http://silver.neep.wisc.edu/~volpe/Publ/1Pub.pdf>

- **F. Volpe**  
*Weakly relativistic dielectric tensor for arbitrary wavenumbers*  
Phys. Plasmas **14**, 122105 (2007)
- A.Mueck, L.Curchod, Y.Camenen, S.Coda, T.P.Goodman, H.P.Laqua, A.Pochelon, L.Porte, **F. Volpe**, TCV Team  
*Demonstration of Electron Bernstein Wave Heating in a Tokamak via O-X-B Double Mode Conversion*  
Phys. Rev. Lett., **75**, 175004 (2007)

- **F.Volpe**  
*Sensitivity of ITER ECRH Upper Launcher to Steering Errors and Changes of Profiles and Integration with Equatorial Launcher*  
Journal of Phys.: Conf.Series **25**, 283 (2005)
- H.P.Laqua, H.Maassberg, N.Marushchenko, **F.Volpe**, A.Weller, W7-AS Team, W.Kasperek and ECRH-Group  
*Electron-Bernstein-Wave Current Drive in an Overdense Plasma at the Wendelstein 7-AS Stellarator*  
Phys. Rev. Lett. **90**, 75003 (2003)
- **F.Volpe**, H.P.Laqua and the W7-AS Team  
*BXO mode-converted electron Bernstein emission diagnostic (invited)*  
Rev. Sci. Instrum. **74**, 1409 (2003)

## Referees

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Dr. Heinrich P. Laqua, *ECRH Deputy Leader*  
Max-Planck-Institut für Plasmaphysik (IPP), Wendelsteinstraße 1, 17491 Greifswald, GERMANY  
laqua@ipp.mpg.de

Dr. Brian Lloyd, *Physics Operation Group Leader*  
UKAEA Fusion, D3 Culham Science Centre, Abingdon, OX14 3DB, UNITED KINGDOM  
brian.lloyd@ukaea.org.uk

Dr. Ron Prater, *Integrated Modelling Area Leader, former Manager of Heating and Current Drive*  
General Atomics, Fusion Group, 3550 General Atomics CT, PO Box 85608, San Diego, CA, USA  
prater@fusion.gat.com

Prof. Friedrich Wagner, *President of the European Physical Society (EPS)*  
Max-Planck-Institut für Plasmaphysik (IPP), Wendelsteinstraße 1, 17491 Greifswald, GERMANY  
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